(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
5 April 2001 (05.04.2001)

PCT

(10) International Publication Number
WO 01/24458 A1

(51) International Patent Classification[7]: H04L 12/28

(21) International Application Number: PCT/US00/26857

(22) International Filing Date: 29 September 2000 (29.09.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

09/408,725	29 September 1999 (29.09.1999)	US
09/439,946	12 November 1999 (12.11.1999)	US
09/438,215	12 November 1999 (12.11.1999)	US
09/544,325	6 April 2000 (06.04.2000)	US

(71) Applicant: MOBILIAN CORPORATION [US/US]; 7431 NW Evergreen Parkway, Suite 220, Hillsboro, OR 97124 (US).

(71) Applicants and
(72) Inventors: NEVO, Ron [IL/US]; 2767 NW Overlook Drive #2311, Hillsboro, OR 97124 (US). MONELLO, Brett, A. [US/US]; 18117 Westminister Drive, Lake Oswego, OR 94037 (US).

(74) Agents: DIEHL, Robert, A. et al.; Columbia IP Law Group, LLC, 4900 SW Meadows Road, Suite 109, Lake Oswego, OR 97035 (US).

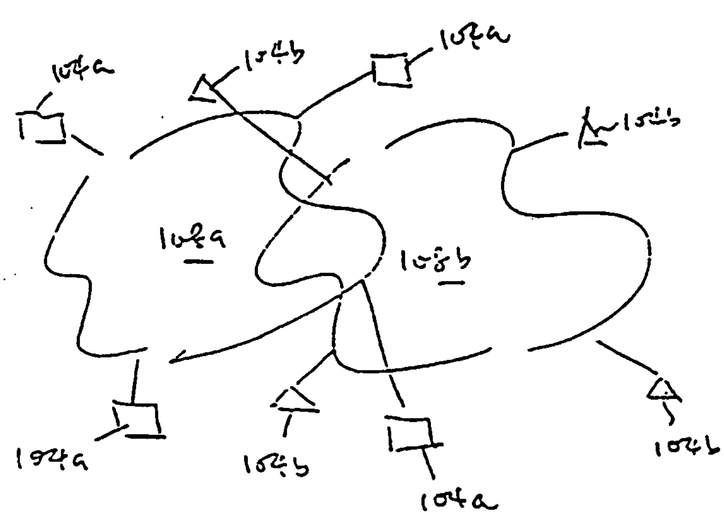
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*
— *Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: WIRELESS COMMUNICATION OF CONCURRENT VOICE AND DATA USING OVERLAPPING PROTOCOLS



(57) Abstract: A wireless device is provided with a wireless transceiver to transmit and receive signals in accordance with a first protocol to and from network devices of a first wireless network, and a controller manager to control operation of the wireless transceiver. The wireless device is further provided with a wireless receiver to receive signals transmitted in accordance with a second protocol by network devices of a second wireless network, and the controller manager is equipped to control operation of the wireless transceiver based at least in part on at least one signaling characteristic of the received signals from network devices of the second wireless network, to reduce interference with proximately located ones of the network devices of the second wireless network. In various iembodiments, the controller manager suspends operation of the wireless transceiver whenever interference is predicted. In other embodiments, the controller manager causes an appropriate filter to be applied whenever interference is predicted.

WO 01/24458 A1

WIRELESS COMMUNICATION OF CONCURRENT VOICE AND DATA USING OVERLAPPING PROTOCOLS

The present U.S. Patent application is a continuation-in-part of U.S. Patent application number 09/439,946, filed November 12, 1999 entitled "MULTIPLE WIRELESS COMMUNICATION PROTOCOL METHODS AND APPARATUSES," which is a continuation-in-part of U.S. Patent application number 09/408,725, filed September 29, 1999, entitled "A WIRELESS APPARATUS HAVING MULTIPLE COORDINATED TRANSCEIVERS FOR MULTIPLE WIRELESS COMMUNICATION PROTOCOLS". The present U.S. Patent application is also a continuation-in-part of U.S. Patent application number 09/438,215, filed November 12, 1999, entitled "WIRELESS APPARATUS INTERFERENCE AVOIDANCE/ RESOLUTION METHODS AND APPARATUSES."

FIELD OF THE INVENTION

The present invention relates to the field of wireless communication. More specifically, the present invention relates to the problem of concurrent wireless voice and data communication with multiple communication partners of different wireless communication protocols.

BACKGROUND OF THE INVENTION

Advances in microprocessor and communication technology have led to the increase in popularity of wireless communication. Once confined to the privileged, wireless voice communication have become affordable and available to the masses. Today, various efforts are under way to apply wireless communication to replace attachment cables used for attaching peripheral devices, such as printers, scanners and the like, as well as networking cables used for connecting clients, servers and the like. Examples of technology to accomplish these goals include the different variants of the IEEE 802.11 Standard published by the Institute of Electrical and Electronic Engineers,

802.11 (Frequency Hopping, Direct Sequence), 802.11a, 802.11b, as well as Home RF, also known as Shared Wireless Access Protocol (SWAP) to those skilled in the art.

It is desirable for various applications (e.g., voice and data) to have wireless devices that operate in accordance with different protocols, and overlapping frequencies, to operate proximately located to each other. Most wireless protocols employ carrier sense collision detection, and random back off to resolve collision or interference. However, experience has shown that prior art collision detection and back off approaches could substantially degrade the performance of both networks operating with overlapping frequencies. Accordingly, an improved approach to allow wireless devices operating with different protocols and overlapping frequencies to operate proximately close to each other is needed.

SUMMARY OF THE INVENTION

A first block of data is transmitted according to a first protocol. A second block of data is transmitted in one of multiple slots in a first packet and one of multiple slots in a second packet according to a second protocol when no conflict exists between transmission of the first block of data and transmission of the first and second packets of the second protocol. In one embodiment, the first packet and the second packet are transmitted at different frequencies. Transmission of one of the first packet and the second packet is blocked when the other of the first packet and the second packet transmitted according to the second protocol conflicts with transmission of the first block of data. Transmission of the first packet and the second packet is blocked when the first packet and the second packet transmitted according to the second protocol conflict with transmission of the first block of data.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings in which like reference numerals refer to similar elements.

Figure 1 illustrates one embodiment of an overlapping network environment incorporated with the teachings of the invention.

Figures 2a-2b illustrate one embodiment of an architectural view and operation flow of "fully" enhanced wireless devices.

Figure 3 is a flow chart of one embodiment support for simultaneous operation of IEEE 802.11 and SWAP.

Figures 4a-4b illustrate one embodiment of an architectural view and operation flow of "fully" enhanced wireless devices in further detail.

Figures 5a-5b illustrate one embodiment of an architectural view and operation flow of "fully" enhanced wireless devices in further detail.

Figures 6a-6b illustrate one embodiment of an architectural view and operation flow of "fully" enhanced wireless devices in further detail.

Figure 7 illustrates the concept of a notch filter.

DETAILED DESCRIPTION

In the following description, various aspects of the present invention will be described. However, it will be apparent to those skilled in the art that the present invention may be practiced with only some or all aspects of the present invention. For purposes of explanation, specific numbers, materials and configurations are set forth in order to provide a thorough understanding of the present invention. However, it will also be apparent to one skilled in the art that the present invention may be practiced without the specific details. In other instances, well known features are omitted or simplified in order not to obscure the present invention.

Parts of the description will be presented using software terminology commonly employed by those skilled in the art to convey the substance of their work to others skilled in the art. As well understood by those skilled in the art, these software quantities take the

form of electrical, magnetic, or optical signals capable of being stored, transferred, combined, and otherwise manipulated through mechanical and electrical components of a digital system; and the term digital system includes general purpose as well as special purpose processors, systems, and the like, that are standalone, adjunct or embedded.

Various operations will be described as multiple discrete steps performed in turn in a manner that is most helpful in understanding the present invention, however, the order of description should not be construed as to imply that these operations are necessarily order dependent, in particular, the order the steps are presented. Furthermore, the phrase "in one embodiment" will be used repeatedly, however the phrase does not necessarily refer to the same embodiment, although it may.

Referring now to **Figure 1**, wherein an overview of an overlapping network environment incorporated with the teachings of the present invention is shown. As illustrated, overlapping wireless network environment **100** includes wireless network devices **104a** of first wireless network **108a** operating in accordance with a first wireless protocol (e.g., SWAP), and wireless network devices **104b** of second wireless network **108b** operating in accordance with a second wireless protocol (e.g., IEEE 802.11). Wireless devices **104a** and **104b** are proximately located to each other, with at least some of wireless devices **104a** and **104b** being sufficiently close, such that when they transmit on the same frequency, they interfere (or "collide" or "conflict") with each other. One or more wireless devices **104a** and **104b** are incorporated with the teachings of the present invention to facilitate proactive interference avoidance or resolution. As a result, the number of conflicts and the number of times wireless devices **104a** and **104b** go through the costly prior art back off, retry approaches are reduced, leading to overall improvement in efficiency for both wireless networks **108a-108b**.

In one embodiment, all devices **104a** are incorporated with the teachings of the present invention to predict when an interference will occur, and proactively avoid or resolve the interference (hereinafter, "fully enhanced" devices). In another embodiment, only some of devices **104a** are so enhanced (one or more). In yet another embodiment, while only some of devices **104a** are so enhanced (one or more), other devices **104a** not so "enhanced" are nevertheless "minimally enhanced" to request the "fully enhanced" devices

104a to at least preemptively notify them on when an interference is predicted to occur (hereinafter, "minimally enhanced" devices). The "fully enhanced" devices **104a** are further equipped to provide the preemptive notifications.

Likewise, in one embodiment, all devices **104b** are incorporated with the teachings of the present invention to predict when an interference will occur, and pro-actively avoid or resolve interference (hereinafter, "fully enhanced" devices). In another embodiment, only some of devices **104b** are so enhanced. In yet another embodiment, while only some of devices **104b** are so enhanced, other devices **104b** not so enhanced are nevertheless "minimally" enhanced to request the "fully enhanced" devices **104b** to at least preemptively notify them on when interference is predicted to occur (hereinafter, "minimally enhanced" devices). The "fully enhanced" devices **104b** are further equipped to provide the preemptive notifications.

In one embodiment, wireless network protocol **108a** is IEEE 802.11b and wireless network protocol **108b** is SWAP 1.1. Other protocols can also be used, for example, IEEE 802.11a, other IEEE 802.11 protocols, other versions of SWAP, etc. In one embodiment, wireless network protocol **108a** uses a 22 MHz range around a center frequency to transmit and receive data. In an alternate embodiment, wireless network protocol **108a** uses a 16 MHz range around a center frequency to transmit and receive data. Other ranges can also be used. In one embodiment, wireless network protocol **108b** transmits and receives both voice and data information on a sequence of frequencies in 20 ms intervals. Furthermore, SWAP packets have two 2.4 ms voice fields and voice information is transmitted in voice fields of two consecutive packets. Thus, voice data is transmitted at two different frequencies.

Figures 2a-2b illustrate the architecture and operational flow of an enhanced wireless device **104b** of **Fig. 1** in accordance with one embodiment (a "fully enhanced" embodiment). Wireless devices **104b** are enhanced to be voluntary dominated devices, allowing wireless devices **104a** to be the dominant devices, to proactively avoid interference. Enhanced wireless devices **104b** are to predict when an interference will occur, and at each of such predicted occurrence, voluntarily suspend operation (for a brief moment) to proactively refrain from interfering with wireless devices **104a**.

As illustrated in **Fig. 2a**, to enable wireless devices **104b** to so operate, each wireless device **104b**, in addition to conventional transceiver **1008** and controller manager **1006**, is additionally provided with state machine **1004**, receiver **1007** and interference avoidance manager **1005**. The elements are coupled to each other as shown.

Receiver **1007** is used to additionally receive signals transmitted in accordance with the first protocol (e.g., IEEE 802.11) between wireless devices **104a**, thus allowing the enhanced wireless device **104b**, to be able to receive signals in the first protocol, in addition to transmitting and receiving signals in the second protocol (e.g., SWAP). Interference avoidance manager **1005** is equipped to determine at least a signaling characteristic of the first protocol, and predicts when an interference will occur, based on the determined one or more signal characteristics. For the illustrated embodiment, interference avoidance manager **1005** determines the frequency used by devices **104a**, and predicts when an interference will occur based on the determined frequency or frequency hopping pattern. The determination may be made in any one of a number of techniques known in the art.

State machine **1004** is used to periodically generate a TX/RX or NOP control signal for controller manager **1006** to control transceiver **1008** accordingly, i.e. to transmit/receive or suspend operation (to proactively avoid interference). State machine **1004** generates the TX/RX or NOP control signal based on whether an interference is predicted by interference avoidance manager **1005**.

As illustrated in **Fig. 2b**, state machine **1004**, in addition to idle state **1010**, has two operating states (S1-S2) **1012-1014**. In state S1, state machine **1004** outputs the TX/RX control signal denoting performance of transmit/receive operation, and in state S2, state machine **1004** outputs the NOP control signal denoting suspension of transmit/receive operation.

Upon power-on or reset, state machine **1004** transitions from idle state **1010** to S1 state **1012**. While in S1 state **1012**, state machine **1004** remains in the state as long as an interference is not predicted by interference avoidance manager **1005**, outputting the TX/RX control signal for controller manager **1006**. Whenever an interference is predicted by interference avoidance manager **1005**, state machine **1004** transitions from S1 state

1012 to S2 state **1014**. While in S2 state **1014**, state machine **1004** remains in the state for a predetermined duration, outputting the NOP signal denoting suspension of transmit/receive operations for controller manager **1006**. The predetermined duration may be "hardwired", denoted through jumpers, or set through configuration registers, and the like. Upon expiration of the predetermined duration, state machine **1004** transitions from S2 state **1014** to S1 state **1012**. From S1 state **1012**, state machine **1004** continues operation as described earlier.

Except for the generation of the TX/RX and NOP control signals, and the control of transceiver **1008** by controller manager **1006** in accordance with these control signals, proactively avoiding interference with wireless device **104a**, each wireless device **104b**, including controller manager **1006** and transceiver **1008**, otherwise operates as known in the art.

Referring again to **Fig. 2a**, in one embodiment, in support of the "minimally enhanced" devices **104b**, interference avoidance manager **1005** further monitors signals received by transceiver **1008** from other devices **104b**. In particular, interference avoidance manager **1005** monitors for requests from other "minimally enhanced" devices **104b** to be preemptively notified of a predicted occurrence of an interference. Upon receiving at least one such request, interference avoidance manager **1005** further causes each prediction to be broadcast for other devices **104b**, thereby allowing the "minimally enhanced" devices **104b** to be able to voluntarily behave as dominated devices (in favor of wireless devices **104a**, the dominant devices).

A "minimally enhanced" device **104b** may be constituted by slightly modifying controller manager **1006**, and additionally provided with only state machine **1007** (i.e., without providing receiver **1007** and interference manager **1005**). Controller manager **1006** is slightly modified to broadcast a request to the "fully enhanced" devices **104b**, to preemptively provide a prediction of interference, as described earlier. The broadcast e.g. may be made upon power on, reset, or periodically. State machine **1007** operates substantially as described earlier, i.e. outputting TX as long as no prediction of an interference occurrence is received, and outputting NOP for a predetermined duration whenever a prediction of an interference occurrence is received.

In one embodiment, in order to avoid conflicts between IEEE 802.11 transactions (transmit or receive) and SWAP transactions, if the SWAP-based transaction falls within the IEEE 802.11 transaction frequency the SWAP packet is not transmitted. As mentioned above, blocks of voice data are transmitted in slots of two consecutive SWAP packets. For a particular block of voice data, if one of the two packets in which the block is transmitted is blocked, the block of data is still transmitted. However, the advantages (e.g., error correction) available from transmitting the block of data twice are reduced.

If both packets in which the block of data is to be transmitted are blocked, the block of data is lost and not transmitted in subsequent packets. As described below, the probability of not transmitting a block of data is relatively low and the block of data represents only 2.4 ms of voice data, which is a relatively small loss.

Because the hop sequence of SWAP is a simple cycle between frequencies in a pseudo-random manner, the number of collisions can be quite low. Table 1 shows the collision probability for each possible IEEE 802.11 band assuming 22 MHz filters are used.

Center Frequency (MHz)	2412	2417	2422	2427	2432	2437	2442
Number of Hits	1	4	2	0	2	4	3
Probability	0.002	0.007	0.003	0	0.003	0.007	0.005
Center Frequency (MHz)	2447	2452	2457	2462	2467	2472	
Number of Hits	5	1	1	0	2	2	
Probability	0.008	0.002	0.002	0	0.003	0.003	

Table 1: Hit probability for IEEE 802.11B with 22 MHz bands and SWAP 1.1

The center frequencies are the possible center frequencies while operating according to IEEE 802.11. The number of hits is the number of consecutive hop pairs that fall within the 22 MHz band of the IEEE 802.11 center frequency. The probability is the probability of a hit assuming a 309 μsec IEEE 802.11 slot with four simultaneous SWAP supported calls.

If 16 MHz band are used with IEEE 802.11 communications, the number of hits is further reduced.

Center Frequency (MHz)	2412	2417	2422	2427	2432	2437	2442
Number of Hits	0	1	0	0	1	1	1
Probability	0	0.002	0	0	0.002	0.002	0.002
Center Frequency (MHz)	2447	2452	2457	2462	2467	2472	
Number of Hits	0	1	0	0	0	1	
Probability	0	0.002	0	0	0	0.002	

Table 2: Hit probability for IEEE 802.11B with 16 MHz bands and SWAP 1.1

The number of hits is the number of consecutive hop pairs that fall within the 16 MHz band of the IEEE 802.11 center frequency. The probability is the probability of a hit assuming a 309 μsec IEEE 802.11 slot with four simultaneous SWAP supported calls. Thus, by using narrower band filters for IEEE 802.11 communications, the amount of SWAP data lost can be reduced.

Figure 3 is a flow chart of one embodiment support for simultaneous operation of IEEE 802.11 and SWAP. Packets are generated according to IEEE 802.11 and/or SWAP at **310**. Generation of data and/or voice packets according to IEEE 802.11 and SWAP are known to those of ordinary skill in the art.

Controller managers **106a** and/or **106b** determine whether a collision will occur between an IEEE 802.11 packet and one or more SWAP packets at **320**. A collision occurs if both transceiver **102a** and transceiver **102b** attempt to transmit or receive packets at the same frequency at the same time. If no collision is detected at **320** the IEEE 802.11 packet and/or the SWAP 1.1 packet are transmitted at **330**. The process then repeats for subsequent transmissions.

If a collision is detected at **320**, the IEEE 802.11 packet is transmitted at **340**. The SWAP packets that cause the collision are aborted at **350**. Any number of SWAP packets can be aborted to avoid a collision. Typically, however, only one or two SWAP packets are aborted. The process then repeats for subsequent transmissions. In one embodiment, aborting the SWAP packet(s) causes 2.4 μsec of voice data to be lost per packet.

Figures 4a-4b illustrate the architecture and operational flow of an enhanced wireless device **104a** of **Fig. 1** in accordance with one embodiment (a "fully enhanced"

embodiment). As described earlier, wireless devices **104a** are enhanced to be the voluntary dominated devices, allowing wireless devices **104b** to be the dominant devices, to proactively avoid interference. In one embodiment, the dominated device is a SWAP device and the dominate device is an IEEE 802.11 direct sequence spread spectrum (DSSS) device. Other configurations can also be provided. Enhanced wireless devices **104a** are to determine when a current frequency interferes with wireless device **104b**, and at each of such determination (or "prediction", albeit with certainty), voluntarily suspend operation (for a brief moment) to proactively refrain from interfering with wireless devices **104b**.

As illustrated in **Fig. 4a**, to enable wireless devices **104a** to so operate, each wireless device **104a**, in addition to conventional transceiver **1108** and controller manager **1106**, is additionally provided with receiver **1107** and interference avoidance manager **1105**. The elements are coupled to each other as shown.

Receiver **1107** is used to additionally receive signals transmitted in accordance with the second protocol between wireless devices **104b**, thus allowing the enhanced wireless device **104a**, to be able to receive signals in the second protocol, in addition to transmitting and receiving signals in the first protocol. Interference avoidance manager **1105** is equipped to determine at least a signaling characteristic of the second protocol, monitor controller manager **1106**, determine if an interference is to occur based on the determined one or more signal characteristics, and proactively avoid the interference. For the illustrated embodiment, interference avoidance manager **1105** determines the signaling frequency of the second protocol, monitors the pseudo random frequency hopping pattern of controller manager **1106**, and determines if a current frequency is the same as the signaling frequency of the second protocol.

As illustrated in **Fig. 4b**, interference avoidance manager **1105** checks for interference, as controller manager **1106** controls transceiver **1108**, hopping from frequency to frequency, **1112**. If the current frequency is not the interfering frequency, interference avoidance manager **1105** allows controller manager **1106** to operate transceiver **1108** as known in the art, **1114**; otherwise, it causes controller manager **1106** to suspend transmit/receive operation, **1116**, pro-actively avoiding interference.

Except for the inclusion of receiver **1107** and interference avoidance manager **1105**, each wireless device **104a**, including controller manager **1106** and transceiver **1108**, otherwise operates as known in the art.

Referring again to **Fig. 4a**, in one embodiment, in support of the "minimally enhanced" devices **104a**, interference avoidance manager **1105** further monitors signals received by transceiver **1108** from other devices **104a**. In particular, interference avoidance manager **1105** monitors for requests from other "minimally enhanced" devices **104a** to be preemptively notified of a "predicted" occurrence of an interference. Upon receiving at least one such request, interference avoidance manager **1105** further causes each prediction to be broadcast for other devices **104a**, thereby allowing the "minimally enhanced" devices **104a** to be able to voluntarily behave as dominated devices (in favor of wireless devices **104b**, the dominant devices).

A "minimally enhanced" device **104a** may be constituted by slightly modifying controller manager **1106** (i.e., without providing receiver **1107** and interference manager **1105**). Controller manager **1106** is slightly modified to broadcast a request to "fully enhanced" devices **104a**, to preemptively provide a prediction of interference, as described earlier. The broadcast may be made e.g. at power on, reset or periodically. Otherwise, controller manager **1107** operates substantially as described earlier, i.e. operating transceiver **1108** to transmit and receive signals as long as no prediction of an interference occurrence is received, and suspending operation of transceiver **1108** for a predetermined duration whenever a prediction of an interference occurrence is received.

Figures 5a-5b illustrate the architecture and operational flow of an enhanced wireless device **104b** of **Fig. 1** in accordance with another embodiment (another "fully enhanced" embodiment). As described earlier, wireless devices **104b** are enhanced to proactively resolve interference. Enhanced wireless devices **104b** are to predict when an interference will occur, and at each of such predicted occurrence, apply an appropriate filter (for a brief moment) to remove interfering signals of wireless devices **104a**. In one embodiment, wireless devices **104a** are SWAP devices and wireless devices **104b** are IEEE 802.11 frequency hopping spread spectrum (FHSS) devices.

As illustrated in **Fig. 5a**, to enable wireless devices **104b** to so operate, each wireless device **104b**, in addition to conventional transceiver **1208** and controller manager **1206**, is additionally provided with receiver **1207** and interference resolution manager **1205**. The elements are coupled to each other as shown.

Receiver **1207** is used to additionally receive signals transmitted in accordance with the first protocol between wireless devices **104a**, thus allowing the enhanced wireless devices **104b**, to be able to receive signals in the first protocol, in addition to transmitting and receiving signals in the second protocol. Interference resolution manager **1205** is equipped to determine at least a signaling characteristic of the first protocol, and predicts when an interference will occur, based on the determined one or more signal characteristics.

For the illustrated embodiment, interference resolution manager **1205** determines the frequency hopping pattern followed by devices **104a**, and predicts when an interference will occur based on the determined frequency hopping pattern. The determination may be made in any one of a number of techniques known in the art. Additionally, interference resolution manager **1205** further determines an appropriate filter to be applied to remove the interfering signals of wireless devices **104a** at each predicted occurrence of interference. In one embodiment, the appropriate filter is a notch filter, inversely formed based on the interfering signal (as illustrated in **Fig. 7**).

Thus, as illustrated in **Fig. 5b**, upon power on or reset, interference resolution manager **1205** monitors the transmit signals of devices **104a** to determine the pseudo random frequency hopping pattern followed by devices **104a**, and the appropriate filter to apply, **1210**. Thereafter, interference resolution manager **1205** determines if an interference is to occur, based on the determined pseudo random frequency hopping pattern, **1212**. Whenever an interference is predicted to occur, interference resolution manager **1205** outputs the appropriate control signal and filtering information for controller manager **1206** to apply the appropriate filter to proactively remove the interfering signals of wireless devices **104a**, **1214**.

Except for the determination of the pseudo random frequency hopping pattern of wireless devices **104a**, the determination of the appropriate filter, predicting when an

interference will occur, and causing controller manager **1206** to apply the determined appropriate filter, each enhanced wireless device **104b**, including controller manager **1206** and transceiver **1208**, otherwise operates as known in the art.

Referring again to **Fig. 5a**, in one embodiment, in support of the "minimally enhanced" devices **104b**, interference resolution manager **1205** further monitors signals received by transceiver **1208** from other devices **104b**. In particular, interference resolution manager **1005** monitors for requests from other "minimally enhanced" devices **104b** to be preemptively notified of a predicted occurrence of an interference. Upon receiving at least one such request, interference resolution manager **1205** further causes each prediction to be broadcast for other devices **104b**, including the appropriate filter to apply, thereby allowing the "minimally enhanced" devices **104b** to be able to also proactively resolve interference.

A "minimally enhanced" device **104b** likewise may also be constituted by merely slightly modifying controller manager **1206**. Controller manager **1206** is slightly modified to broadcast a request to "fully enhanced" devices **104b**, to preemptively provide a prediction of interference, as described earlier. Again, the broadcast may be made e.g. at power on, reset, or periodically. Controller manager **1206** further causes the appropriate filter to be applied to received signals, whenever a prediction of an interference occurrence is received.

Figures 6a-6b illustrate the architecture and operational flow of an enhanced wireless device **104a** of **Fig. 1**, in accordance with another embodiment (another "fully enhanced" embodiment). As described earlier, wireless devices **104a** are enhanced to proactively resolve interference. Enhanced wireless devices **104a** are to predict when an interference will occur, and at each of such predicted occurrence, apply an appropriate filter (for a brief moment) to remove interfering signals of wireless devices **104b**.

As illustrated in **Fig. 6a**, to enable wireless devices **104a** to so operate, each wireless device **104a**, in addition to conventional transceiver **1308** and controller manager **1306**, is additionally provided with receiver **1307** and interference resolution manager **1305**. The elements are coupled to each other as shown.

Receiver **1307** is used to additionally receive signals transmitted in accordance with the second protocol between wireless devices **104b**, thus allowing the enhanced wireless device **104a**, to be able to receive signals in the second protocol, in addition to transmitting and receiving signals in the first protocol. Interference resolution manager **1305** is equipped to determine at least a signaling characteristic of the second protocol, determine if an interference is to occur based on the determined one or more signal characteristics, and proactively avoid the interference. For the illustrated embodiment, interference avoidance manager **1105** determines the signaling frequency of the second protocol. Additionally, interference resolution manager **1305** further determines an appropriate filter to be applied to remove the interfering signals of wireless devices **104b** at each predicted occurrence of interference. In one embodiment, the appropriate filter is also a notch filter, inversely formed based on the interfering signal (as illustrated in **Fig. 7**).

Thus, as illustrated in **Fig. 6b**, upon power on or reset, interference resolution manager **1305** monitors the transmit signals of devices **104b** to determine the signaling frequency of devices **104b**, and the appropriate filter to apply, **1310**. Thereafter, interference resolution manager **1305** monitors the pseudo random frequency hopping pattern of controller manager **1306**, and determines if the current frequency is the same as the signaling frequency of devices **104b**, **1312**. If the current frequency is not the interfering frequency, interference resolution manager **1305** allows controller manager **1306** to operate transceiver **1308** as known in the art, otherwise, interference resolution manager **1305** outputs the appropriate control signal, including the filtering information, to cause controller manager **1306** to apply the appropriate filter to the received signals, to proactively resolve interference, **1314**.

Except for the inclusion of receiver **1307** and interference resolution manager **1305**, each wireless device **104a**, including controller manager **1106** and transceiver **1108**, otherwise operates as known in the art.

Referring again to **Fig. 6a**, in one embodiment, in support of "minimally enhanced" devices **104a**, interference resolution manager **1305** further monitors signals received by transceiver **1308** from other devices **104a**. In particular, interference resolution manager **1305** monitors for requests from other "minimally enhanced" devices **104a** to be

preemptively notified of a "predicted" occurrence of an interference. Upon receiving at least one such request, interference resolution manager **1305** further causes each prediction to be broadcast for other devices **104a**, thereby allowing the "minimally enhanced" devices **104a** to also proactively resolve interference.

A "minimally enhanced" device **104a** may likewise be constituted by merely slightly modifying controller manager **1306** (i.e., without providing receiver **1307** and interference manager **1305**). Controller manager **1306** is slightly modified to broadcast a request to "fully enhanced" device **104a**, to preemptively provide a prediction of interference and associated filtering information, as described earlier. Otherwise, controller manager **1307** operates substantially as described earlier, i.e. operating transceiver **1308** to transmit and receive signals as long as no prediction of an interference occurrence is received, and proactively filters received signals whenever a prediction of an interference occurrence is received.

Thus, wireless devices equipped to proactively avoid interference have been described. While the present invention has been described in terms of the above illustrated embodiments, those skilled in the art will recognize that the invention is not limited to the embodiments described. The present invention can be practiced with modification and alteration within the spirit and scope of the appended claims. For example, in each of the "filtering" embodiments, the appropriate filtering may be "recursively" or "incrementally" determined. As a further example, each of enhanced wireless devices **104a** and **104b** may be further enhanced to allow the pro-active interference avoidance/resolution function to be configurably enabled or disabled. The description is thus to be regarded as illustrative instead of restrictive on the present invention.

CLAIMS

What is claimed is:

1. A method comprising:

transmitting a first block of data according to a first protocol;

transmitting a second block of data in one of multiple slots in a first packet and one of multiple slots in a second packet according to a second protocol when no conflict exists between transmission of the first block of data and transmission of the first and second packets of the second protocol, wherein the first packet and the second packet are transmitted at different frequencies;

blocking transmission of one of the first packet and the second packet when the other of the first packet and the second packet transmitted according to the second protocol conflicts with transmission of the first block of data; and

blocking transmission of the first packet and the second packet when the first packet and the second packet transmitted according to the second protocol conflict with transmission of the first block of data.

2. The method of claim 1 wherein the first protocol comprises IEEE 802.11 protocols.

3. The method of claim 1 wherein the second protocol comprises Shared Wireless Access Protocol (SWAP).

4. The method of claim 1 wherein the second protocol communicates voice data.

5. The method of claim 1 wherein data transmitted according to the second protocol is voice data.

6. The method of claim 1 wherein packets communicated according to the first protocol are for use with a first network and packets communicated according to the second protocol are for use with a second network.

7. The method of claim 1 further comprising adaptively managing time sharing between packets communicated according to the first protocol and packets communicated according to the second protocol.

8. The method of claim 7 wherein adaptively managing time sharing is based, at least in part, on transmit or receive workloads of a first wireless transceiver and a second wireless transceiver that communicate according to the first protocol and the second protocol, respectively.

9. A machine-readable medium having stored thereon sequences of instructions that, when executed, cause one or more electronic systems to:

transmit a first block of data according to a first protocol;

transmit a second block of data in one of multiple slots in a first packet and one of multiple slots in a second packet according to a second protocol when no conflict exists between transmission of the first block of data and transmission of the first and second packets of the second protocol, wherein the first packet and the second packet are transmitted at different frequencies;

block transmission of one of the first packet and the second packet when the other of the first packet and the second packet transmitted according to the second protocol conflicts with transmission of the first block of data; and

block transmission of the first packet and the second packet when the first packet and the second packet transmitted according to the second protocol conflict with transmission of the first block of data.

10. The machine-readable medium of claim 9 wherein the first protocol comprises IEEE 802.11 protocols.

11. The machine-readable medium of claim 9 wherein the second protocol comprises Shared Wireless Access Protocol (SWAP).

12. The machine-readable medium of claim 9 wherein data transmitted according to the second protocol is voice data.

13. The machine-readable medium of claim 9 wherein packets communicated according to the first protocol are for use with a first network and packets communicated according to the second protocol are for use with a second network.

14. The machine-readable medium of claim 9 further comprising sequences of instructions that, when executed, cause the one or more electronic systems to adaptively manage time sharing between packets communicated according to the first protocol and packets communicated according to the second protocol.

15. The machine-readable medium of claim 14 wherein adaptively managing time sharing is based, at least in part, on transmit or receive workloads of a first wireless transceiver and a second wireless transceiver that communicate according to the first protocol and the second protocol, respectively.

16. An apparatus comprising:

a first wireless transceiver to transmit a first block of data according to a first protocol; and

a second wireless transceiver to transmit a second block of data in one of multiple slots in a first packet and one of multiple slots in a second packet according to a second protocol when no conflict exists between transmission of the first block of data and transmission of the first and second packets of the second protocol, wherein the first packet and the second packet are transmitted at different frequencies, to block transmission of one of the first packet and the second packet when the other of the first packet and the second

packet transmitted according to the second protocol conflicts with transmission of the first block of data, and to block transmission of the first packet and the second packet when the first packet and the second packet transmitted according to the second protocol conflict with transmission of the first block of data.

17. The apparatus of claim 16 wherein the first protocol comprises IEEE 802.11 protocols.

18. The apparatus of claim 16 wherein the second protocol comprises Shared Wireless Access Protocol (SWAP).

19. The apparatus of claim 16 wherein data transmitted according to the second protocol is voice data.

20. The apparatus of claim 16 wherein packets communicated according to the first protocol are for use with a first network and packets communicated according to the second protocol are for use with a second network.

21. The apparatus of claim 16 further comprising a control circuit coupled to the first wireless transceiver and to the second wireless transceiver, the control circuit to adaptively manage time sharing between packets communicated according to the first protocol and packets communicated according to the second protocol.

22. The apparatus of claim 21 wherein adaptively managing time sharing is based, at least in part, on transmit or receive workloads of the first wireless transceiver and the second wireless transceiver.

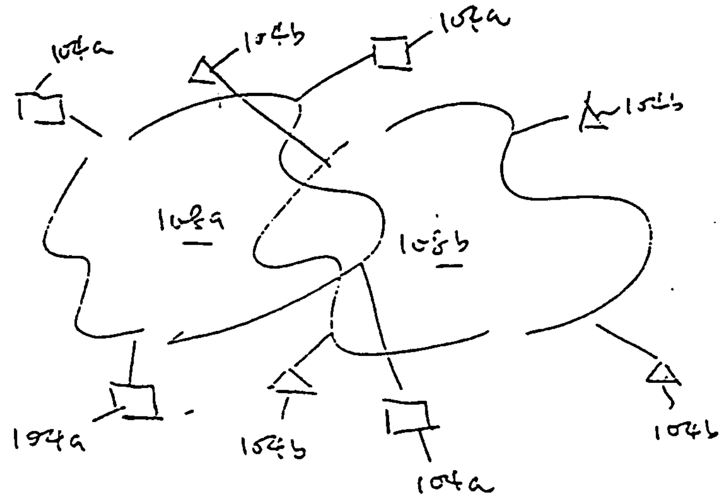


FIG. 1

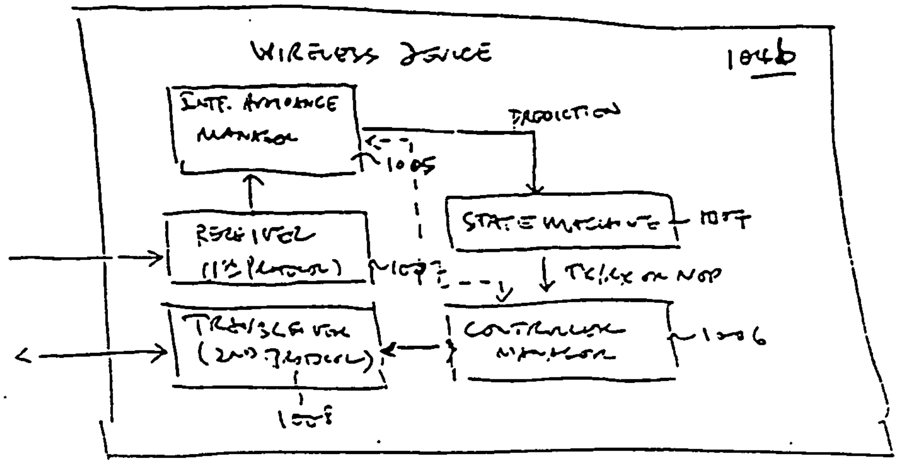

WIRELESS DEVICE
1046
INT. AVOIDANCE MANAGER
PREDICTION
1005
RECEIVER (1ST PROTOCOL)
1002
STATE MACHINE
1007
TX/RX OR NOP
TRANSCEIVER (2ND PROTOCOL)
CONTROLLER MANAGER
1006
1008

FIG. 2a

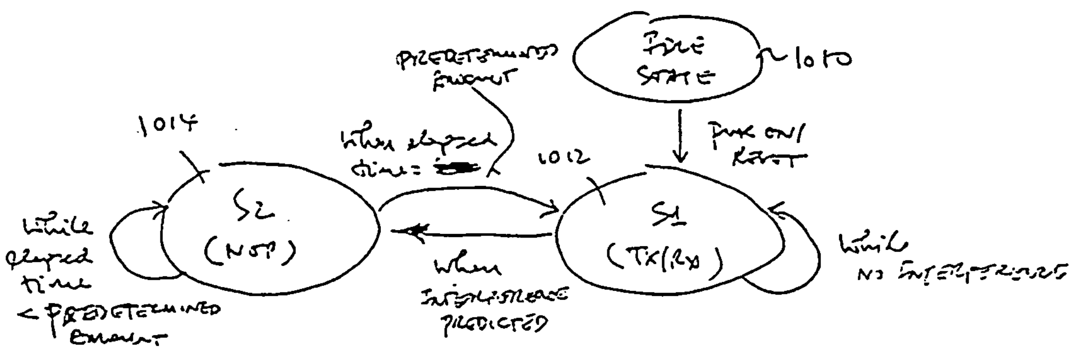

IDLE STATE
1010
POWER ON/ RESET
1014
1012
S2 (NOP)
S1 (TX/RX)
when elapsed time =
PREDETERMINED AMOUNT
when INTERFERENCE PREDICTED
while elapsed time < PREDETERMINED AMOUNT
while NO INTERFERENCE

FIG. 2b

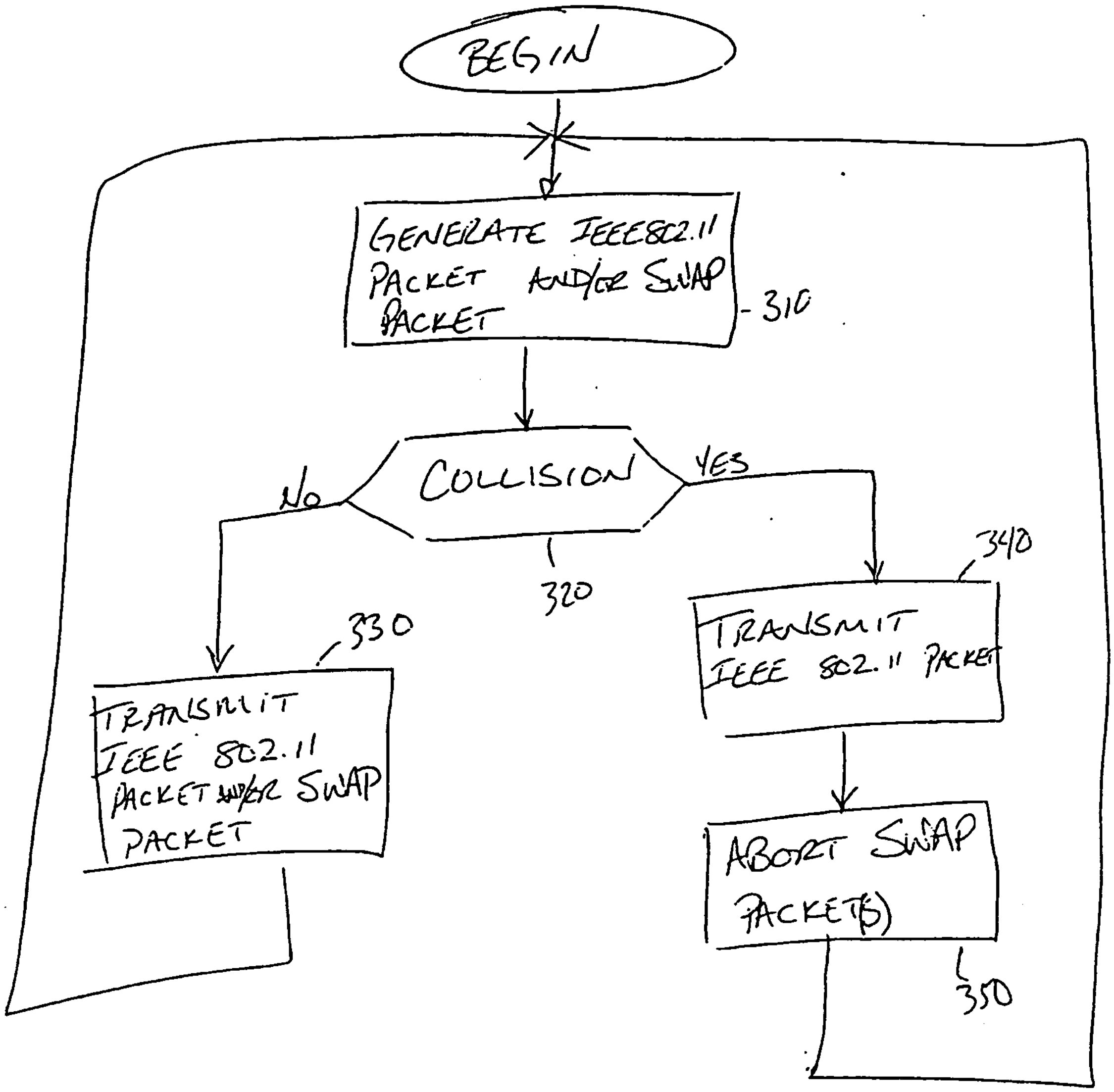

BEGIN
GENERATE IEEE802.11 PACKET AND/OR SWAP PACKET
310
COLLISION
NO
YES
320
TRANSMIT IEEE 802.11 PACKET AND/OR SWAP PACKET
330
TRANSMIT IEEE 802.11 PACKET
340
ABORT SWAP PACKET(S)
350

Fig. 3

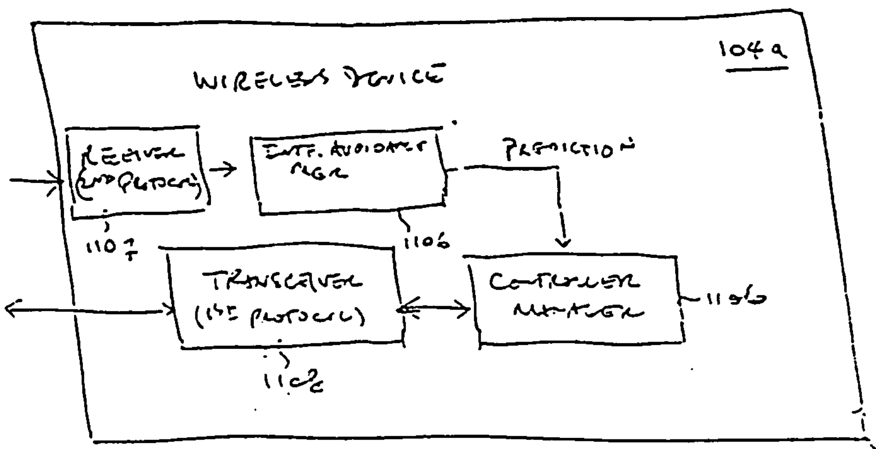

104a
WIRELESS DEVICE
RECEIVER (2ND PROTOCOL)
INTF. AVOIDANCE MGR
PREDICTION
1107
1106
TRANSCEIVER (1ST PROTOCOL)
CONTROLLER MANAGER

FIG. 4a

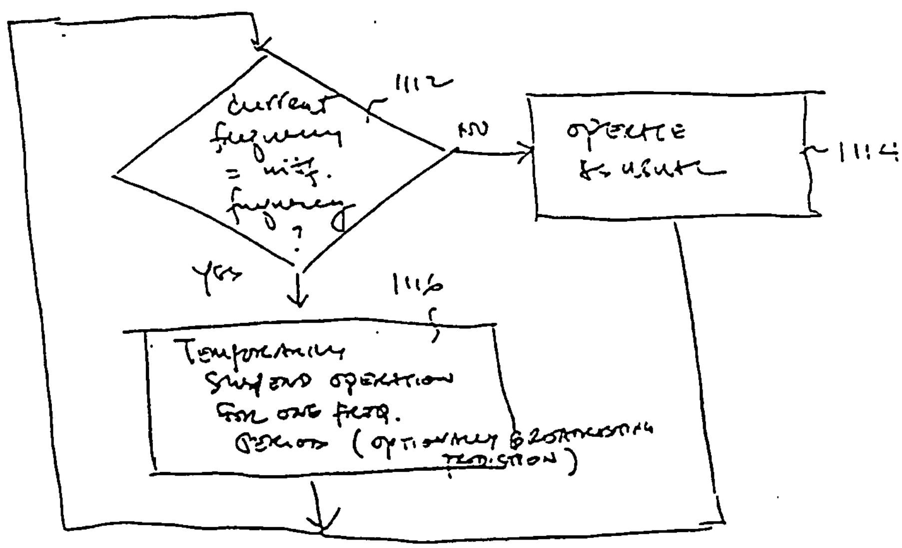

current frequency = intf. frequency ?
1112
NO
OPERATE AS USUAL
1114
YES
1116
TEMPORARILY SUSPEND OPERATION FOR ONE FREQ. PERIOD (OPTIONALLY BROADCASTING PREDICTION)

FIG. 4b

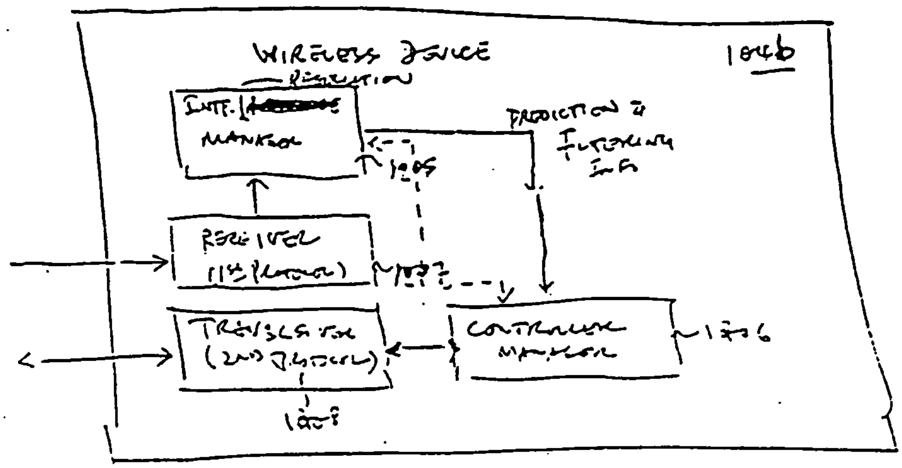

WIRELESS DEVICE
1046
INTF. PREDICTION
MANAGER
PREDICTION &
FILTERING
INFO
1208
RECEIVER
(1ST PROTOCOL)
TRANSCEIVER
(2ND PROTOCOL)
CONTROLLER
MANAGER
1206

FIG. 5a

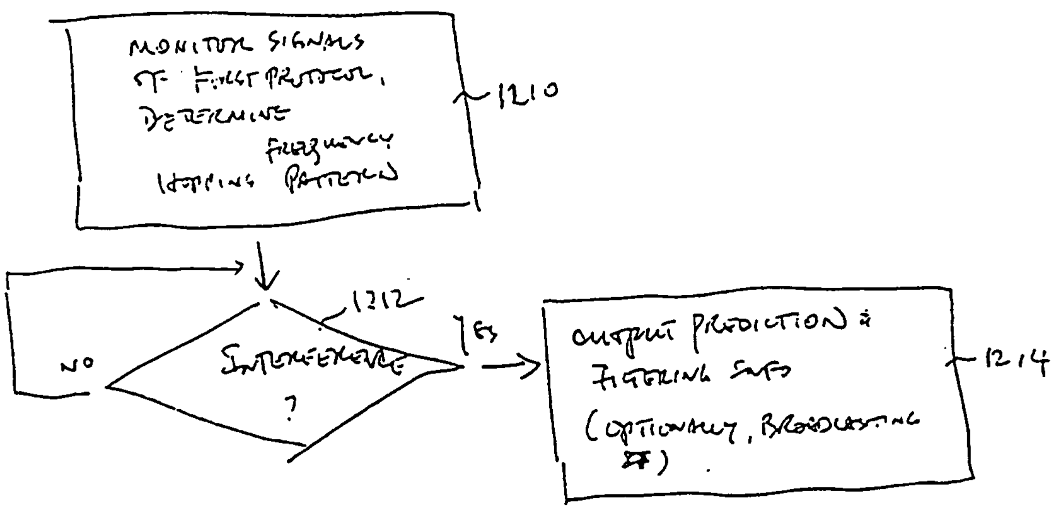

MONITOR SIGNALS
OF FIRST PROTOCOL,
DETERMINE
FREQUENCY
HOPPING PATTERN
1210
1212
NO
INTERFERENCE
?
YES
OUTPUT PREDICTION &
FILTERING INFO
(OPTIONALLY, BROADCASTING
IT)
1214

FIG. 5b

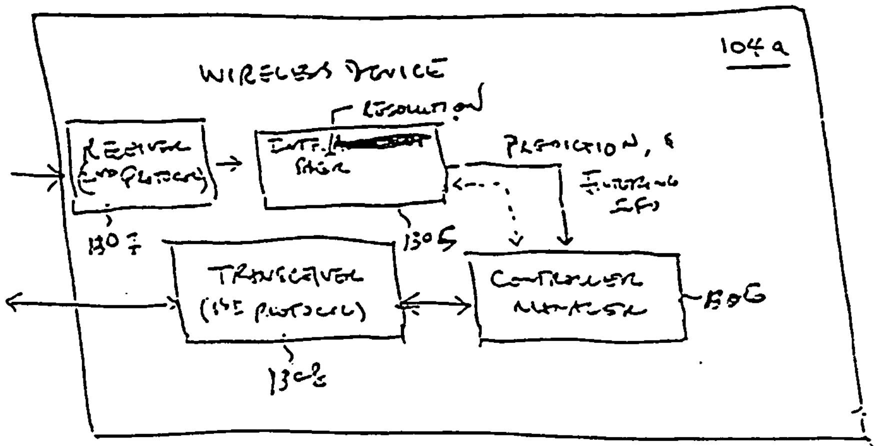

WIRELESS DEVICE
104a
RESOLUTION
RECEIVER (2ND PROTOCOL)
INTF. STAGE
PREDICTION, & FILTERING INFO
1307
1305
TRANSCEIVER (1ST PROTOCOL)
CONTROLLER MANAGER
1306
1308

FIG. 6a

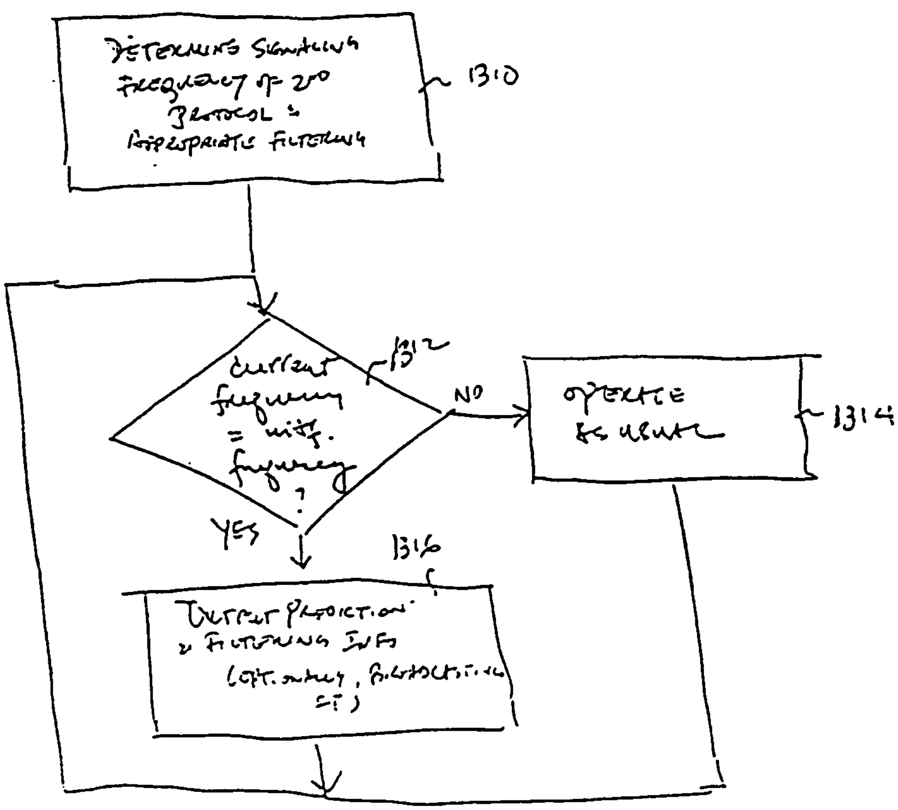

DETERMINE SIGNALING FREQUENCY OF 2ND PROTOCOL & APPROPRIATE FILTERING
1310
current frequency = intf. frequency ?
1312
NO
OPERATE AS USUAL
1314
YES
1316
OUTPUT PREDICTION & FILTERING INFO (OPTIONALLY, BROADCASTING IT)

FIG. 6b

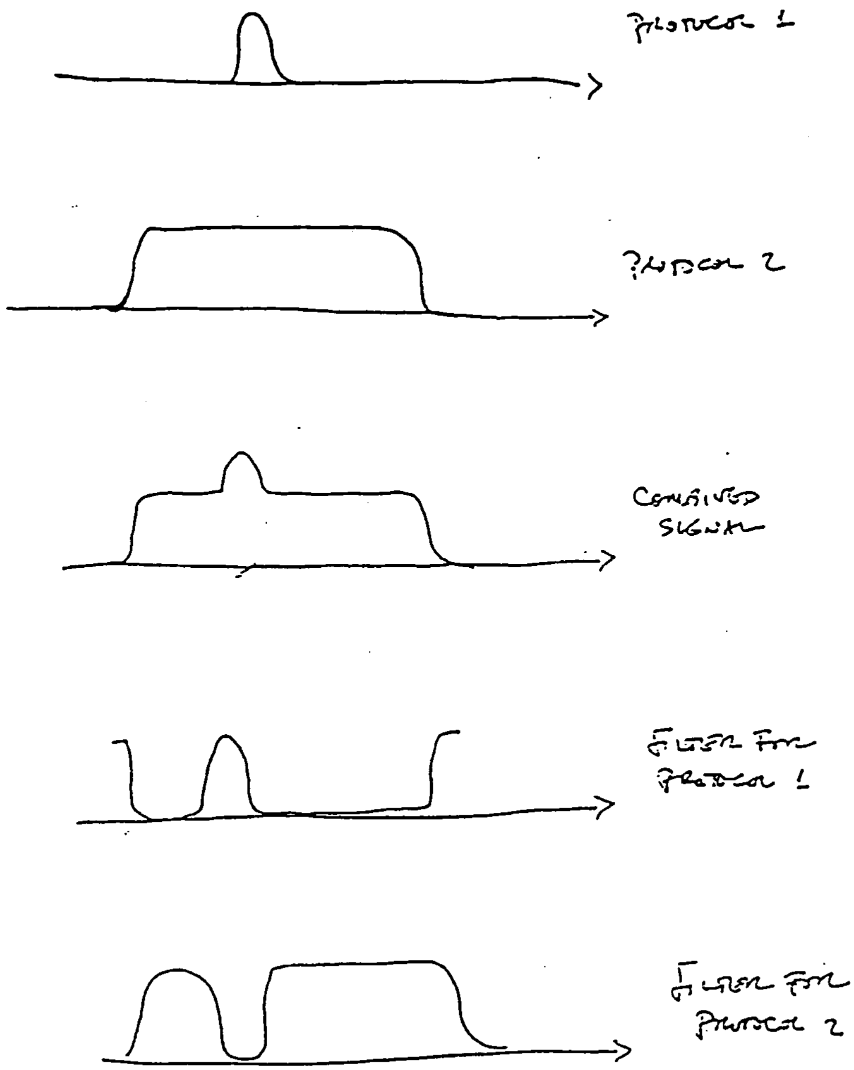

Protocol 1
Protocol 2
Combined signal
Filter for protocol 1
Filter for protocol 2

Fig 7

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/26857

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L12/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04Q H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 99 29126 A (JOERESSEN OLAF J ;NOKIA MOBILE PHONES LTD (FI)) 10 June 1999 (1999-06-10) page 1, line 5 -page 3, line 4 page 5, line 12 - line 14 page 7, line 1 - line 4 page 11, line 20 -page 13, line 24 figures 4,5,7,8 ---	1,4,5,7, 9,12-14, 16,19-21

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 January 2001	06/02/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Barel, C

1

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	NEGUS K J ET AL: "HOME RF TM AND SWAP: WIRELESS NETWORKING FOR THE CONNECTED HOME" MOBILE COMPUTING AND COMMUNICATIONS REVIEW,US,ACM, NEW YORK, NY, vol. 2, no. 4, 1 October 1998 (1998-10-01), pages 28-36, XP000786057 page 29, right-hand column, last paragraph - page 30, left-hand column, paragraph 2 page 33, left-hand column, paragraph 1-2	3,11,18

1

INTERNATIONAL SEARCH REPORT

.iormation on patent family members

Interr   nal Application No
PCT/US 00/26857

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9929126 A	10-06-1999	AU 1500299 A	16-06-1999
		EP 1038409 A	27-09-2000
		GB 2347321 A	30-08-2000